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Notes on the Geology of West Virginia. By I. O. White.

(Read before the American Philosophical Society, October 20, 1882.)

The Geology of the Cheat river Cañon along its course through Laurel Hill and Chestnut Ridge, between Albright (near Kingwood), in Preston county, and Ice's Ferry, in Monongalia county.

The material for the present paper has been gradually accumulated on class excursions from the University during the last five years.

Cheat river takes its rise on the summit of that great plateau, near the Randolph-Pocahontas line, from which so many large streams radiate to every point of the compass, the Elk, Greenbrier, James, Potomac, Monongahela and Cheat, all having the source of their principal branches on this plateau at an altitude of more than 3000 feet above the sea.

From this elevated divide, several branches—Dry, Laurel, Globe and Shaver's—flow northward in narrow, parallel valleys, into the southern portion of Tucker county, where meeting Black Fork from the north-east, they unite to form the main Cheat river which with many windings continues its general course almost due north to Albright, the south-eastern limit of the district under examination. Here, however, it veers to the north-west and maintains that general direction for the next twenty-five miles to Ice's Ferry, in Monongalia county, where it again veers north and unites with the Monongahela river just north from the W. Va.-Penna. line.

At Albright, the channel of the river is in the bottom of the syncline between the Viaduct and Laurel Hill axes, and its north-west course for twenty-five miles carries it squarely through Laurel Hill, Chestnut Ridge and the great synclinal plateau between them. Throughout this twenty miles (about twenty-five by the river), Cheat river flows in a wild cañon cut down 1000'–1500' below the summits of the bordering mountains whose slopes are so rocky and precipitous that but a single human dwelling is in sight along the river, from where one enters the cañon below Albright, until he emerges from it near Ice's Ferry.

The Great Conglomerate, or No. XII, carrying the *Lower Coal Measures* on its top, crowns the steepest portion of the cañon throughout its entire length, and its immense boulders constantly block the narrow channel of the river, thus giving a wildness and grandeur to the scenery unsurpassed anywhere along the course of this famous stream.

But unrivaled as is the scenic beauty of this cañon, it presents still greater attractions for the geologist in the splendid natural exposures of the *Great Conglomerate* and *Sub-carboniferous* rocks that it affords; for under the arches of Laurel and Chestnut Ridges one may find many almost clean exposures from the top of No. XII down nearly to the base of No. X. To place some of these magnificent sections before those interested in Carboniferous geology is the principal object of this paper, and in order to accomplish this systematically we shall begin with the section at Ice's Ferry, and pass south-eastward up the Cheat river to Albright.

At this ferry, the road leading from Morgantown, W. Va., to Uniontown, Pa., crosses the river which, emerging from the cañon of No. XII, one mile above, now flows between low hills of the *Barren measures* with the *Mahoning sandstone* making bold cliffs along the immediate banks

About one-fourth mile above the ferry, a small stream puts into the west bank of Cheat over the Mahoning sandstone cliffs, and descending it from the Morgantown road near Mr. Bayles, the following succession may be seen, Sec. 1:

1. *Coal (crinoidal)*..... 1'
2. *Shales, gray*.....10'
3. *Shales, red*.....25'
4. *Shales and concealed*.....45'
5. *Shales, brown, sandy*.....10'
6. *Coal, Bakerstown*..... 2½'
7. *Sandy shales and shaly sandstone*.....50'
8. *Upper Mahoning sandstone*, very massive and pebbly. 30'
9. *Shaly sandstone*, intermingled with *slaty coal* and representing *Brush creek coal* of Pennsylvania.... 3'
10. *Sandy Shales*..... 7'
11. *Lower Mahoning sandstone*, visible.....85'
12. *Concealed to level of Cheat river*.....10'

No. 1 is the coal which so frequently occurs directly under the *Green Crinoidal limestone* in south-west Pennsylvania and the adjoining regions in West Virginia. It is quite impure and is well exposed at the roadside, some distance north-west from Mr. Bayles'.

No. 3 is the very persistent bed of red, marly shales which so constantly, underlie the *Crinoidal limestone* in Pennsylvania and West Virginia, even retaining their place unfailingly in the series when the latter disappears.

The *Bakerstown coal*, No. 6, occurs along the Morgantown road near the toll-gate at Mr. Bayles', and is of fair quality. I have identified it with the coal bed occurring 100' below the *Crinoidal limestone*, described as the *Bakerstown coal* in my Report Q, on North Allegheny county, Pennsylvania. These coals of the *Barrens* are of course sporadic and irregular in distribution, and their identification over wide areas would seem at first thought hazardous in the extreme, but as the principal beds always come in at certain well defined stratigraphical horizons there can be less objection to such identification than to a constant multiplication of local names to represent the same geological horizon, hence as the coal in question comes about 100' below the *Crinoidal limestone*, I have thought it preferable to use the *Bakerstown* name even though the coal marshes in which each was formed may never have been connected with one another.

The *Upper Mahoning sandstone*, No. 8, is very conglomeratic at this locality, so much so that it was once extensively quarried for mill stones on the opposite side of the river.

The *Brush creek coal* is feebly represented in the section by a bed of black coal slate interstratified with thin layers of sandstone, immediately under the *Upper Mahoning sandstone*.

The *Lower Mahoning Sandstone* is not pebbly at this locality, and is rather inclined to be flaggy, though some portions of it are quite massive.

The *Upper Freeport coal* lies about 10' below the level of Cheat river at the mouth of Bayles' run, where our section ends. On the east bank of the stream, it rises above drainage and was once mined as fuel for the Laurel Iron Works, situated one-half mile below. The coal is reported four feet thick and of good quality.

In passing up the river south-eastward from the ferry, the rocks rise very rapidly toward the *Chestnut Ridge axis*, and the top of No. XII makes its appearance above river level in a massive dam-like wall, just below Mr. Ley's, and not quite a mile above the ferry.

The intervening *Lower Coal Measures* are not well exposed, being concealed by the immense heaps of talus under the cliffs of Mahoning sandstone, but a vertical measurement from the outcrop of the *Upper Freeport coal* where seen along the Bruceton turnpike opposite Mr. Ley's, down to the top of the No. XII Conglomerate makes their thickness 250'. The only coals in these measures here are the *Upper Freeport*, and one that comes about 160' below it, being $1\frac{1}{2}$ '-2' thick, and very excellent coal. It is either the *Middle* or *Lower Kittanning*, most probably the latter.

Continuing on up the river above Mr. Ley's, the rocks rise about 400'-450' to the mile, and bring the top of the *Mauch Chunk shales* (No. XI) above river level at the mouth of Quarry run, a small stream that empties into the east bank of Cheat, one mile and a half above Ice's Ferry. It cuts a fine exposure through No. XII and in descending to the river along its right bank this section was got, Sec. 2 :

1. Sandstone, massive, <i>Homewood</i> , top of XII.....	25'	Pottsville
2. Concealed.....	40'	
3. Very massive pebbly sandstone.....	75'	
4. Coal { coal 0' 10" } <i>Quakertown coal?</i>	1' 4"	177'
{ sandstone 0' 3" }		
{ coal 0' 3" }		
5. Black, slaty shale.....	10'	conglomerate.
6. Sandstone, gray, massive.....	20'	
7. <i>Shale with streaks of coal</i>	1'	
8. Sandstone, grayish-white, massive, base of No. XII.....	15'	Mauch Chunk
9. Shales, green, containing I. O., top of No. XI.....	20'	
10. <i>Red shales</i>	10'	
11. Greenish sandy shales and flaggy sandstone.....	60'	30' Shales.
12. Concealed to mouth of old oil well boring.	25'	
13. Flaggy sandstone and shales (Mr. Ley's authority) in oil boring.....	185'	
14. <i>Limestone, Umbral, Mountain, &c</i>	85'	
15. Sandstone, (<i>Vesperine</i> , No. X) to bottom of hole.....	700'	

The section of No. XII, obtained at this locality, is quite interesting from the fact that it reveals this series much thinner than it had always been estimated on Cheat river. Owing to the difficulty of finding exposures at the immediate base of No. XII, much of the underlying massive rock in the Mauch Chunk shales has heretofore been included in No. XII on Cheat river, thus giving it a thickness of 300'-350'. The above section shows the true base of No. XII in an unmistakable manner, and shows that this series has a thickness of only 180' at the locality in question.

The uppermost member, No. I, which corresponds to the *Homewood SS.* of the Penna. Survey reports, is a very massive, grayish-white rock, making a bold cliff around the mountain side, 20 to 30 yards back from No. 3, from which it is separated by a concealed interval of 40' at this locality. This No. 2 is probably a shale or flaggy sandstone interval and may possibly contain a small coal bed, since the *Mercer series* of Penna. is due in this horizon.

No. 3 is the conglomerate portion of No. XII and is seen in one immense overhanging cliff along the right bank of Quarry run. It is a grayish-white rock, often exhibiting a buffish tinge, and contains many quartz pebbles scattered in layers throughout its mass, being largest and most numerous in the uppermost 25'. None were seen larger than chestnuts.

This stratum would seem to harmonize with the *Upper Connoquenessing sandstone* of the *Conglomerate series* in western Pennsylvania. It is the great cliff rock along the Cheat river cañon.

Immediately below this last stratum, there comes a very interesting little bed of coal which is quite persistent for many miles along Cheat river, being generally separated into two layers by a thin sandstone or shale as shown in the section, and always underlain by a thick bed of black, fissile slate. The bed is fully exposed for a distance of 200 yards at the base of the great cliff along Quarry run, and its variations are there beautifully shown. Occasionally the sandstone comes down and cuts it out entirely for a few feet, but it suddenly comes in again at the same horizon. It never gets thicker than 2' and seems to be quite pure, simulating the "block" coals in physical aspect. Since it appears to come at the same geological horizon as the *Quakertown coal* of Lawrence Co., Pennsylvania. I have doubtfully referred it to that bed.

A diligent search was made in the *black shale*, No. 5, for *fossil plants*, but as yet none have been found except some macerated fragments of *Cordaites*.

Nos. 6-8 seem to represent the *Lower Connoquenessing SS.* of Penna.; the older, *Sharon conglomerate*, being in my opinion unrepresented in the section.

In passing from No. XII to the rocks of XI, there is a wonderful change in the lithology of the rocks, the massive, coarse, grayish white beds of

XII being replaced by a green sandy shale which the geologist instantly recognizes as belonging in the subcarboniferous beds. The junction of XII and XI is finely exposed for several rods at this locality, and the former seems to rest with a *slight unconformity* on No. XI. In the top of No. XI, at the horizon of No. 9, occur valuable deposits of *iron ore* all along the Cheat river mountains on each side of Chestnut Ridge, and they were formerly extensively mined and used at the Henry Clay, Laurel, Green Spring and other furnaces. It is known as the "*Swisher*," and "*Mountain*" *ore*, and was mined by both drifting and stripping, the bed sometimes attaining a thickness of 2 feet.

Were there any doubt about No. 9's being the top of XI, No. 10 would resolve it, for *red shale* is a factor unknown in No. XII. This *red bed* seems to hold a constant place in the *Mauch Chunk series* along Cheat river, having been seen at this same horizon in many localities. The section from No 13 down, was given me by Mr. Ley, who assisted in drilling a well for oil near the mouth of Quarry run. As will be seen from the section, it makes the *Mauch Chunk shale* 300' thick, and the *Mountain Limestone* 85'.

No. 15, is very probably not all No. X, but the lower portion doubtless penetrates the *Catskill*, or *Chemung*, if the former be absent as Prof. Stevenson claims.

In passing up Cheat river from the mouth of Quarry run, the rocks rise quite rapidly, and at one-half mile south-east from the locality of the last section, all of the *Mauch Chunk shale*, and nearly half of the *Mountain Limestone* have appeared above water-level, where on the left bank of Cheat, they reveal this succession (Sec. 3) :

1. Sandstone, current-bedded.....	10'	} Mauch Chunk Shale.
2. Concealed	15'	
3. Red shale.....	10'	
4. Limestone, fossiliferous, impure.....	8'	
5. Shales, red and green.....	15'	
6. Shales, marly.....	5'	
7. Limestone, grayish-white, massive.....	25'	} Mountain Limestone.
8. Shale, calcareous, very fossiliferous.....	1'	
9. Limestone, massive, gray, to level of Cheat river (850' A. T. by Bar).....	15'	

This little section is interesting from the fact that it exhibits a structure in the basal portion of the *Mauch Chunk shale*, which is quite common in Fayette and Westmoreland counties. In those counties Prof. Stevenson (see Repts. KK, and KKK 2d Geol. Survey of Pa.), finds *one* and sometimes *two thin limestones* several feet above the base of the *Mauch Chunk shale*, and the same feature is present all along the Cheat river Cañon, as far up as Rowlesburg at least, where I find *three thin limestones* within an interval of 70' above the *Mountain Limestone*. (See The Virginias for July, 1882.)

The *limestone*, No. 4, of the above section, is quite impure, having a brecciated appearance, and is fossiliferous, *Spirifers* and *Producti* being especially numerous. No. 7 was once extensively quarried at this locality, and used for flux at the old charcoal furnaces near Ice's Ferry. It is quite pure, making a beautiful white lime much valued for plastering purposes. It is possible that some portions of the stone might be successfully employed as a flux in the manufacture of glass.

The thin calcareous shale, No. 8, is a perfect mass of fossils, among which *Allorisma clavata*, *Hemipronites crassus*, *Athyris subtilita*, *A. subquadrata*, *Spirifer Keokuk*, *Productus cora*, and *Crinoidal fragments* are most numerous.

Continuing south-eastwards up the river, the rocks still rise with great rapidity, and at one mile and a half above the last locality, only $2\frac{1}{2}$ miles from where the top of No. XII first emerges from the bed of Cheat, we get the following succession in descending the almost vertical wall on the right bank of the river (Sec. 4) :

1. Very massive pebbly sandstone.....	20'	} No. XII.
2. Concealed	80'	
3. Sandstone, massive, coarse.....	20'	
4. Concealed	45'	} Mauch Chunk shale.
5. Shales and concealed.....	20'	
6. <i>Red shale</i>	10'	
7. Sandstone, greenish, current-bedded.....	165'	
8. <i>Red</i> , and green shales and concealed.....	50'	
9. <i>Limestone</i> , impure.....	10'	} No. X.
10. Shales, green and red	25'	
11. Flaggy sandstone and shales.....	15'	
12. <i>Mountain limestone</i> , in layers 1'-10' thick separated by thin calcareous shales.....	95'	} No. X.
13. Sandstone, finely laminated, and containing pebbles of limestone.....	10'	
14. "Silicious limestone," grayish-white.....	5'	
15. Sandstone, flaggy.....	10'	
16. Sandstone, massive, pebbly, current-bedded	80'	
17. Concealed to level of Cheat river (875 A. T.)	200'	

I have placed the base of No. XII in this section, 45' below the top of the concealed interval, since the band of *red shale*, No. 6, is evidently identical with the one in Sec. 2, which comes 20' below the base of XII. This gives a thickness of 165' for the latter at this locality, and since 10'-15' have been eroded from its top, the group when complete would have about the same thickness as found in Sec. 2 (177').

The *Mauch Chunk shale* foots up a thickness of 295' at this locality, which is so near that given by the combined section and boring in Sec. 2 (300'), that the latter figure may be taken as the average thickness of these

beds along the Cheat river cañon through Chestnut Ridge and Laurel Hill.

The sandstone in No. 7 gets quite massive at times, and this portion of the column makes a great bluff along either bank of the river, from which the descent to the stream is almost vertical in many places.

As will be seen by comparing the sections, the interval between the *Mountain limestone* and the 10' *impure limestone* above, is in this section just double that in Sec. 3, showing that it is quite variable.

The *Mountain limestone*, No. 12, juts out of the bluff in a great cliff at this point, and was once quarried for flux for the old Henry Clay furnace, situated near the head of Quarry run.

No. 14 seems to be identical with the "Silicious limestone" of Stevenson in Fayette and Westmoreland counties, and is here clearly a portion of No. X, since 10' of *Pocono* or *Vespertine sandstone* comes above it.

No. 16 is a massive, hard, gray sandstone, containing streaks of small quartz pebbles, and forming an immense cliff along the mountain side.

About one-fourth mile above the last locality, another section taken on the same (east) bank of Cheat river reveals the following structure (Sec. 5) :

1. Massive sandstone, and conglomerate, making lower half of No. XII.....	100'	Mauch Chunk shale.	No. X 435'	
2. Concealed.....	50'			
3. Sandstone, flaggy, and current-bedded.....	160'			
4. Layer of breccia.....	2'			
5. Concealed and red shale.....	40'			
6. <i>Limestone</i> , impure.....	5'			
7. <i>Red shale</i> , and concealed.....	35'			
8. <i>Mountain limestone</i> , visible.....	85'			
9. Concealed.....	25'			
10. " <i>Silicious limestone</i> ,".....	10'			
11. Sandstone, massive, pebbly.....	100'			
12. Concealed with flaggy sandstone at base....	175'			
13. Concealed to Cheat river (885' A. T.).....	150'			

This section is but a repetition of the preceding one, with slight variations, the *Silicious limestone* being here 10' thick instead of 5'. It is a light gray rock, containing possibly 40-50 per cent. of lime, and would make as good pavement blocks as that from Westmoreland Co., so extensively used in Pittsburgh and vicinity.

No. 4 is a curious layer of shale, iron ore, and sandstone pebbles cemented into a matrix of impure limestone.

The rocks still rise quite rapidly south-eastward as we approach the *Chestnut Ridge axis* which crosses Cheat river about one mile and a quarter above the locality of Sec. 5.

About one-half mile south-east from the locality of the last section, a small rivulet falls over the base of No. XII, and completely exposes the

beds at the junction of No. XI, with the former, exhibiting the following in descending the steep east bluff of the river (Sec. 6) :

1. Conglomerate, very massive.....	100'	} No. XII.	180'
2. Sandstone, coarse, few pebbles.....	50'		
3. Shales, sandy, buff, containing some I. O....	20'		
4. Sandstone, massive, buff.....	10'		
5. Shales, yellow, and green, containing I. O...	30'	} Mauch Chunk	293'
6. Sandstone, greenish, somewhat flaggy.....	140'		
7. <i>Layer of breccia</i> , calcareous.....	2'		
8. Sandstone, green, flaggy.....	20'		
9. <i>Layer of breccia</i> , calcareous.....	1'		
10. Shales, red and green.....	45'	} shale.	No. X
11. <i>Limestone</i> , impure.....	10'		
12. <i>Red shales</i> , and flaggy sandstone.....	45'		
13. <i>Mountain limestone</i>	100'		
14. " <i>Silicious limestone</i> ," and Pocono sandstone..	125'		
15. Concealed to level of Cheat river.....	450'		575'

I was at first disposed to place the line between Nos. XII and XI at the base of No. 2 in the above section, but the massive yellowish sandstone, No. 4, so unlike anything usually found in No. XI, determined its base as the true dividing horizon between the two series. This is also confirmed by the thicknesses which result from placing it there, viz.: 180' for XII and 293' for XI shales, which are almost exactly the same as found for each in Sec. 2.

The "*Silicious limestone*" is 10'-15' thick at this locality and as usual passes insensibly into the great sandstone deposit below.

A few rods further south from the last locality another measurement of the beds gave this result (Sec. 7) :

1. Massive, pebbly sandstone.....	150'	} No. XII.	185'
2. Shales and shaly sandstone, buff.....	35'		
3. Shales, greenish, sandy.....	30'		
4. Sandstone, greenish-gray, flaggy.....	90'		
5. <i>Red and green shales</i>	12'	} Mauch Chunk	299'
6. Sandstone, greenish, massive at top, flaggy and shaly below.....	65'		
7. <i>Brecciated limestone</i>	2'		
8. <i>Red and green shales</i>	25'		
9. Blue sandy shales, and green flaggy SS....	25'		
10. <i>Limestone</i> , impure, fossiliferous.....	10'	} Shale.	
11. Red and green shales and sandstone.....	40'		
12. <i>Mountain Limestone</i>			

(a.) Massive limestone in layers 1'—5' thick, sparingly fossiliferous.....	25'	} 110'
(b.) Shaly limestone and calcareous shales, very fossiliferous, especially rich in <i>Productus</i> , <i>Spirifer</i> , <i>Athyris</i> , <i>Lophophyllum</i> and <i>Cri-</i> <i>noidal columns</i>	5'	
(c.) Limestone, gray, good, few fossils.....	45'	
(d.) Shales and limestone.....	35'	
13. "Silicious limestone," passing gradually into sandstone below.....	30'	} No. X. 605.
14. Sandstone, massive, pebbly, current-bedded, making cliffs.....	100'	
15. Concealed to level of Cheat river.....	475'	

Here the "Silicious limestone" runs down into the underlying sandstone to a depth of 30' and finally fades into sandstone so imperceptibly that it is impossible to fix the line between the two.

Just above this locality, about one-fourth mile, the *Chestnut Ridge axis* crosses Cheat river, four and a half miles from Ice's Ferry. At the latter locality the top of No. XII. is 300' under the river, while here at the axis its top comes about 1300' above Cheat river, or 1400' higher than at Ice's Ferry, since the stream falls nearly 100' between the two points.

Here, at the crest of the axis, the Great Conglomerate makes a broad and gentle arch, being almost horizontal for nearly a mile and a half. Its outcrop is traversed as usual by great intersecting fissures which are often 3'—4' wide, and separate the stratum into immense blocks, some of which 50' on a side, have toppled over into the steeply sloping edge of the cañon, and look from a distance as though a slight push would dislodge them into the great chasm beneath.

The scenery along the crest of this great arch is the grandest and most picturesque to be found on this river, famous for its wildness for a distance of nearly 200 miles. There are two points from which the outlook is especially fine, one of these known as *Hanging Cliff View* is on the east side of the river and about one mile above the locality of the last section. Here the river bends sharply westward and a long, narrow ledge of No. XII. sandstone, extends in a bold cliff far out into the main course of the cañon. From this elevated point, the eye takes in a radius of 25 to 30 miles for nearly three-quarters of the horizon; to the south-east one looks up through the great gorges carved by the river out of Laurel Hill and Briery mountain, to the vicinity of Rowlesburg (30 miles distant), where on a clear day, the white puffs of steam and smoke from the B. & O. R. R. engines may be distinctly seen, as the heavily laden trains wind up the steep slopes of the Alleghanies to Cranberry Summit, the lofty peaks of whose surrounding mountains loom proudly against the horizon; to the west and north, the eye has an unobstructed view down the cañon and out over its fast receding walls, to the great plateau of the

Coal Measures, which sculptured into endless forms of hill and dale stretches away to the limit of vision, in delightful contrast to the rugged mountains on the east. Add to this the wild dash of the river as it rushes along over its rocky bed, more than a thousand feet almost vertically below, disappearing in a silver thread far up and down the cañon, and we have a picture enchanting in the extreme.

The other point is Brock's View, named in honor of the late Dr. H. W. Brock, of the W. Va. University, who first discovered the beauties of this portion of the cañon. It is on the opposite side of the river from the Hanging Cliff, nearly one mile below, and is scarcely inferior in grandeur to the latter.

In descending from Hanging Cliff View to the river the following structure is visible (Sec. 8) :

1. Massive conglomerate	75'	} No. XII
2. Concealed to base of XII.....	110'	
3. Concealed.....	190'	} Mauch Chunk 300' Shale.
4. Shales, red, green, &c., containing an impure limestone just below the centre.....	100'	
5. Sandstone, greenish-gray, current-bedded.....	10'	
6. <i>Mountain Limestone</i>	95'	
7. Concealed, with occasional showing of lime- stone and shales	60'	
8. Concealed to level of Cheat river.....	425'	

In descending from the same Hanging Cliff to a point one-half mile further up the river, and just below the "Beaver Hole," the following succession was observed (Sec. 9) :

1. Massive conglomerate, visible	65'	} No. XII
2. Concealed to base of No XII.....	120'	
3. Concealed	60'	} Mauch Chunk 295' Shale.
4. Sandstone, green, flaggy.....	25'	
5. Concealed, but showing frequent outcrops of green, flaggy sandstone.....	195'	
6. Sandstone, green, massive, visible	5'	
7. Concealed.....	10'	
8. <i>Mountain Limestone</i>	120'	
9. " <i>Silicious Limestone</i> "	30'	
10. <i>Pocono sandstone</i> , massive and pebbly at top, hard and flaggy below to the level of Cheat river	425'	

The *Mountain Limestone* contains some extensive caverns along Cheat river, and one not far from the locality of this section has been named the *Eagle Cave*, from the fancied resemblance of one of its stalagmitic accumulations to the outspread figure of an eagle. It has been followed into the mountain side for several hundred yards, and those who have explored it, report some extensive rooms in this cavern.

The "Beaver Hole" mentioned above is a locality just above the Hanging Cliff View, where the current of the stream flows around the circumference of a circle about 150 yards in diameter, and is six miles above Ice's Ferry by the river, but probably not more than five in a direct line.

Continuing up the river from this point toward the south-east, the rocks dip rapidly down, and when we come to the mouth of Sandy creek, four miles above the Beaver Hole, the top of No. XII is only 400' above the level of the stream, instead of 1300', at the crest of the Chestnut Ridge axis. Here at the mouth of Sandy creek we are in the centre of the great trough or syncline between the Chestnut Ridge and Laurel Hill axes. This syncline enters Preston county from Fayette county, Pa., and extends in a south-west course entirely across Preston. The trough is about seven miles wide (from Chestnut Ridge axis to Laurel Hill axis) on Cheat river, but opens out rapidly south-westward from the dying down of its western rim (Chestnut Ridge axis), so that at the B. & O. R.R., near Independence, its breadth is not far from 12 miles.

The *Lower Coal Measures* shoot into the air on Chestnut ridge, but arching over, come down into this Preston county syncline, with 200 to 300 feet of the *Barrens* on top of them, so that at the mouth of Sandy creek, the *Upper Freeport Coal* comes into the immediate river hills. Sandy creek flows down the centre of the syncline from the east, removing a large portion of the *Barrens*, and near its mouth cutting a wide gap in the *Lower Coal Measures*, and a narrow gorge through No. XII.

In the same way, Bull run flows down the central line of the syncline from the west, emptying into Cheat one-half mile below the mouth of Sandy. It, too, has eroded a large hole from the *Lower Coal Measures*, but on cutting down to No. XII is suddenly arrested, and flows along on its top for nearly a mile until approaching the river, it cuts through the massive beds of that series, in several great cascades, giving splendid exposures of the rocks.

In descending the mountain from Mrs. Spurgeon's (opposite the mouth of Sandy creek), to Bull run, and thence down that stream to Cheat river, the following section (10) was constructed :

1. Upper Mahoning Sandstone, massive, visible...	20'		
2. Concealed (spring at 50').....	90'		
3. <i>Upper Freeport Coal</i> {			
coal, slaty.....	1' 0"		
coal, good ...	2' 0"		
shale.....	0' 3"		
coal.....	1' 6"	7'	
shale.....	1' 0"		
coal, good....	1' 6"		
4. Concealed.....	10'		
5. <i>Upper Freeport limestone</i>	12'		
6. Concealed.....	75'		
7. Sandstone, massive, visible (Freeport).....	10'		
8. Concealed.....	90'		
9. <i>Coal blossom</i> (Kittanning Lower).....	—		
10. Shales, containing "kidney" I. O.....	10'		
11. Concealed and sandy shales.....	50'		

Lower Coal

Measures

264'

12. Sandstone, flaggy and massive.....	30'	} No. XII. 194'
13. Massive sandstone, pebbly.....	60'	
14. Very pebbly bed.....	5'	
15. Massive sandstone, scattering pebbles.....	65'	
16. Shale, dark, containing fossil plants.....	10'	
17. Coal, Quakertown? { coal..... 10'' } { shale..... 3'' } { coal..... 5'' }	1' 6''	
18. Fire clay.....	7'	
19. Black, fissile slate	15'	
20. Concealed.....	90'	
21. Shales, reddish.....	35'	
22. Sandstone, rather massive, greenish.....	35'	
23. Concealed, with occasional outcrop of green, flaggy sandstone to level of Cheat river at mouth of Bull run (960 A. T. Bar).....	65'	

The structure of the Upper *Freeport* coal and limestone as given above. was obtained at a new opening on the road which crosses Bull run above Swindler's mill, and leads southward. The coal has been mined on the land of Mrs. Spurgeon in the immediate line of the section, but the opening had fallen in when I visited the locality, and the coal could not be seen. The coal is pitchy black with resinous lustre, is rather free from pyrite, and has every physical appearance of a good coking coal. The central bench just below the 3'' shale, is not so good as the rest of the bed, being somewhat slaty on the outcrop.

The Upper *Freeport* limestone is fully exposed in the ravine below the coal, and seems quite pure throughout, being light gray, very compact, and breaking with a sharp clean fracture. It contains a minute, *univalve fossil*.

The basal portion only of the *Freeport* sandstone (No. 7) is visible; it is a coarse, grayish-white, micaceous sand rock, specked with ferric oxide, and very much resembles the same bed in western Pennsylvania.

The great sand-rocks of No. XII are completely exposed at this locality, and as will be seen from the section contain *no coal* until we come down to the *Quakertown* horizon, the *Homewood* sandstone having merged with the underlying beds, thus shutting out the *Mercer* coal and shale series at this locality, and giving us 160' of rock in one solid mass.

The little coal bed, No. 17, is identical with that given in Sec. 2, at the mouth of Quarry run, and here, as there, is also double, and underlain by a large bed of *black slate*. The coal is quite pure, and contains much *mineral charcoal*. In the dark shales above it, were seen some fragments of *Cordaites* and *leaves of Lepidodendron*.

In the section at Quarry run, 35' more of No. XII, principally massive grayish-white sandstones, occur below this coal, but here, on Bull run, everything is concealed at this horizon, and the character of the interven

ing rocks can only be conjectured. The topography would make them *shales*, and hence I think it probable that the sand rocks seen at Quarry run are absent here, and that the *black slate*, No. 19, rests immediately upon the *Mauch Chunk beds*, but should it prove otherwise, the base of No. XII would then be found about 30' below the top of No. 20, thus making the entire thickness of this series 225' instead of 194', as given in the section.

The top of the *Mountain Limestone* must lie about 100' below the level of Cheat river at this locality, where the centre of the syncline crosses.

At the mouth of Sandy creek, a massive, buffish-gray sandstone makes a bold cliff along the water's edge at 975' A. T. (B), and 220' below the base of No. XII.

As we pass up the river south-eastwards from the mouth of Sandy, the rocks begin to rise in that direction, and at one mile and a half above, the *Mountain Limestone* has completely emerged from the bed of the river, revealing the following structure along a steep ravine which puts into the west bank of Cheat (Sec. 11):

1. Gray sandstone, somewhat massive.....	20'	} Mauch Chunk.
2. Flaggy sandstone and sandy shales.....	150'	
3. <i>Limestone</i> , impure.....	10'	
4. Concealed and green sandy shales	30'	
5. <i>Red shale</i>	10'	} Mountain Limestone 94
6. <i>Limestone</i> , massive, gray.....	40'	
7. Blue shale and impure limestone.....	4'	
8. Shaly <i>limestone</i>	5'	
9. Gray, calcareous shale.....	2'	
10. <i>Limestone</i> in massive beds, 1'-5' thick.....	40'	
11. Green shale.....	1'	
12. Red shale	2'	
13. <i>Silicious Limestone</i> .	<div> <div>{</div> <div>sandy limestone..... 2'</div> <div>blue limestone, rather pure.. 4'</div> <div>silicious limestone, passing gradually into sandstone below..... 2'</div> </div>	} 8'
14. Gray sandstone (Pocono) to level of Cheat..	10'	

This section is valuable, because it gives the first complete exposure that we have had between the *Mountain Limestone* and the "*Silicious*" beds, showing them separated here by 3' of red and green shales, and thus allying the "*Silicious limestone*" more closely with the Pocono SS. into which it passes by insensible gradations.

In continuing on up the river from this locality, the rocks still rise to the southeast, though not much faster than the bed of Cheat, since its fall is very rapid over this portion of its course.

In the vicinity of the "Great Falls," four miles above the mouth of Sandy creek, the west wall of the cañon, capped at top by the sandstone

of XII, becomes almost vertical, and give a very complete exposure of the rocks as shown in the following section (No. 12) obtained there :

1. Flaggy sandstone and concealed.....	25'	No. XII, 220'
2. Massive sandstone, top of <i>Homerwood</i>	25'	
3. Concealed.....	90'	
4. Sandstone, very massive, pebbly.....	50'	
5. Sandstone, grayish white, somewhat flaggy..	55'	
6. Green shales.....	15'	Mauch
7. Concealed, with blossom of <i>coal</i>	10'	
8. Green shales and sandstone.....	130'	295'
9. Sandstone, somewhat massive.....	25'	Chunk.
10. Greenish, flaggy sandstones.....	135'	
11. Limestone and red shale.....	25'	Mountain
12. Limestone.....	65'	
13. Limestone, interstratified with red shale.....	20'	120'
14. Red shale.....	10'	Limestone
15. "Silicious limestone".....	35'	
16. Sandstone, massive, <i>Pocono</i> , to level of Cheat river, at Great Falls (1055' A. T. Bar)....	50'	

No. XII is here 220' thick, or nearly 50' greater than at Quarry run in Sec. 2, and it is possible that it should also include the 25' of flaggy sandstone at the top of the section.

Small chunks of *coal* were seen mingled with other debris in the concealed interval, No. 7, and if they belong there, the bed would be in the *Mauch Chunk shale*, for No. 6, above, is unquestionably Subcarboniferous.

The "*Silicious limestone*" attains a thickness of 35' at this locality, and even then it is doubtful, if I have carried it down far enough, since 10'-15' more of the underlying *sandstone* possesses a very *limy* aspect in the great cliff which rises perpendicularly from the river at the Falls. The whole stratum is one solid mass from the top of No. 15 down to river level, the *Silicious limestone*, as well as the sandstone below exhibiting current bedding.

The "Falls" at this locality is a very rapid descent of the river for several rods over the massive portion of the *Pocono sandstone*, the stream descending about 10' in as many rods.

The following section (13) was obtained about 300 yards above the Falls, in descending a timber chute where the logs in their rapid descent have removed the surface debris from several localities on the west bank of the river :

1. <i>Upper Freeport Coal</i> , reported.....	7'	No. XII. 225'
2. Concealed.....	200'	
4. Sandstone, massive, top of XII.....	50'	
5. Concealed.....	175'	
6. <i>Red shale</i>	10'	
7. Sandstone, flaggy greenish.....	40'	
8. Sandstone, coarse, buff.....	3'	
9. <i>Red shale with I. O. nodules</i>	10'	
10. Sandstone, green, flaggy, visible.....	50'	
11. Concealed to level of Cheat river.....	320'	

The *Upper Freeport coal* given in this section, has been opened along the road on the land of Mr. Graham, about one mile south-west from the top of the river bluff at No. 3, so that the interval of 200' between the coal and No. XII, given by the barometer, should very probably be increased by 50'-75', since the beds decline in that direction (S. W.).

As we pass on south-eastward up Cheat river from the Falls, the rocks still continue rising gently for about two miles, when they turn over in the broad arch of Laurel Hill, and descend, carrying the limestones and shales of No. XI below river level, and finally submerging No. XII itself at Albright, in the centre of the trough, where the western bluff of the river reveals the following section (14) of the *Lower Coal measures* :

1. Sandstone, somewhat massive, Mahoning ?.....	30'
2. Concealed.....	55'
3. Shale, drab.....	15'
4. Sandstone.....	2'
5. Shale and fireclay.....	8'
6. Shale, green, sandy.....	10'
7. Sandstone, gray, massive, <i>Freeport</i>	30'
8. Shale, drab.....	15'
9. " dark blue.....	8'
10. Coal, <i>Middle Kittanning (Darlington)</i>	2'-3'
11. Concealed.....	5'
12. Limestone, nodular, (<i>Johnstown cement bed</i>).....	2'
13. Concealed.....	23'
14. Sandy shale.....	7'
15. Sandstone, greenish.....	13'
16. Shale, visible.....	5'
17. Concealed to level of Cheat river at Albright bridge (1200' A. T. Bar), and to top of No. XII, here in bed of river.....	25'
Total height of section.....	255

From the thickness of the measures in the above section, it would seem that the *Upper Freeport coal* should be looked for immediately under the base of No. 1, which according to this identification would be the *Lower Mahoning sandstone*, but still it is possible that the *Lower coal measures* are here thicker than usual on Cheat river, and in that event the *Upper Freeport coal* would overshoot the top of this section.

No. 7 is undoubtedly the representative of the *Freeport sandstone* of Pennsylvania, while the coal, No. 10, would seem to be the *Middle Kittanning*, or *Darlington bed* of Western Pennsylvania, if Mr. Franklin Platt's identification of the latter with the coal overlying the *Johnstown cement bed* be correct; for the coal in question is here underlain by a grayish, nodular limestone that would well represent the "*cement bed*."

The coal is quite good and has been gouged out of the hill to the depth

of a few feet for more than one-half mile in the vicinity of Albright's bridge, its rapid dip into the hill preventing systematic mining.

Just above the bridge, the *Homewood sandstone* rises from the bed of the river and makes a bold cliff along its north-eastern bank, revealing under it a small *coal bed* beneath a few feet of shales.

On above this to the south-east, the other members of No. XII. come up, and make the steep north-west slope of Briery mountain.

I shall close this paper with a single suggestion in regard to the parallelism of the beds along the Cheat river that I have included under the name *Mauch Chunk shale*.

A review of the sections will show that this interval, extending from the base of XII down to the top of the *Mountain Limestone*, has a thickness of about 300', and can be subdivided into three well marked groups: 1st, at top, a *shale interval* often containing *iron ore* and one or more thin *red beds*, thickness 30'—50'; 2d, a series of flaggy, green sandstones, often having a quite massive bed near the top, and sometimes containing *calcareous bands* 1'—2' thick, thickness 165'; 3d, a series of red and green shales in which usually occur one or more thin beds of impure limestone, thickness down to the main mass of *Mountain Limestone*, 80'—100'.

Those who have read my summary of the Geology of Crawford and Erie counties, Pa., in Report Q⁴, will recall that I there show the "Cuyahoga shale," of Dr. Newberry to be a very composite series, having a structure somewhat as follows, beginning with the base of XII, and descending to the *Berea Grit* (Corry sandstone):

Shenango shales	35'—50'
Shenango sandstone	25'
Meadville Upper shales.....	20'
" " Limestone.....	1'
" Lower shales.....	45'—55'
Sharpsville Upper sandstone.....	50'
Meadville Lower limestone.....	2'
Sharpsville Lower sandstone.....	12'
Orangeville shales	75'
Berea Grit.....	—
Total average thickness about.....	280'

The above succession, I have traced southward from Crawford county to the mouth of the Beaver river at the Ohio, more than half way to Cheat river, and in oil borings at Beaver falls, Smith's ferry and other localities, the series is still 270'—280' thick.

As is well known, the geologists of the 2d Geological Survey of Pennsylvania, who have studied the *Sub-conglomerate measures* in the western counties, have all heretofore placed the dividing line between XI and X, in the *Shenango shales*, and regarded the massive sandstone below them as the beginning of the *Pocono*.

It will be seen at a glance that the "Mauch Chunk shale," interval on

Cheat river has a striking stratigraphical resemblance to the "Cuyahoga series" in Western Pennsylvania, a shale interval at top and bottom with an intervening sandstone interval—Shenango—Sharpsville Lower—of practically the same thickness in each case. The query here suggested is, can the "*Mauch Chunk shale*" interval, 300' thick on Cheat river in Monongalia and Preston counties, be identical with the "*Cuyahoga shale*" series as given above from the Ohio line counties in Pennsylvania? The answer is yet quite doubtful, but the only evidence obtained at present, seems to point to an affirmative reply.

Stratigraphy gives an answer decidedly in the affirmative, for the succession in each case is practically the same, and yet we must not forget that the nearest points to which the series have been traced—mouths of Beaver and Cheat rivers—are separated by some 60 miles, in which these beds are buried from sight by the overlying Coal Measures. It should be stated, however, that the lithology of the 165' sandstone series on Cheat river is often strikingly like that of the *Sharpsville beds* in Pennsylvania, and also that it sometimes contains, near its top, a massive brown sandstone that would correlate well with the *Shenango SS.*

But what say the *fossils* to this supposed parallelism?

On Cheat the "*Mauch Chunk beds*" are not fossiliferous, so that we cannot compare them directly in this respect.

The "*Cuyahoga*" beds are often quite fossiliferous, however, and the evidence that they furnish is curious, as showing an apparent contradiction in the answer to our query given by two classes of organisms—*Mollusks* and *Fishes*.

The *Meadville limestones* in the "*Cuyahoga*" beds are, in Crawford county, filled with *remains of fishes, scales, bones, teeth, dermal structures, &c.,* and in the Spring of 1880 I sent some of these fossils to Prof. Worthen, the eminent Palicthyologist of Illinois, for his opinion as to their geological horizon. He replied that they seemed to him to belong unquestionably with the *fish beds* of the *Chester limestone* at the west, and I should add that this remark of Prof. Worthen first suggested to me the possibility of an identity between the "*Mauch Chunk shales*" of Cheat river, and the "*Cuyahoga*" series.

The *Molluscan remains* found in the "*Cuyahoga*" series, however, seem to ally them more closely with the *Waverly sandstones* (Pocono), which underlie the shales and limestones of No. XI, and in my Report on Crawford and Erie preference was given to their side of the story. It now seems possible, as suggested above, that the testimony of the *Fishes* may yet have to be received in preference to that of their more lowly cousins, the *mollusks*, and the "*Cuyahoga shales*" of Newberry, relegated to the horizon of No. XI, where they were long ago placed by Prof. Lesley on general stratigraphical grounds (see his scheme of Ohio and Pennsylvania formations correlated in Report I, 2nd Geo'l Sur. Pa.).

The apparent contradiction in the evidence given by the two classes of

organisms may be satisfactorily explained, when it is remembered that the open sea in which the great Mountain Limestone of Cheat river—the Chester, St. Louis, and other beds of the West—accumulated, shoaled away to a beach line of muddy shallows in Eastern Ohio and Western Pennsylvania, similar in every respect to the *Waverly* and *Pocono* beaches that had preceded them, and consequently we should expect to find the life forms that had inhabited the latter, continuing on with but slight changes up into the edges of the Mauch Chunk series, where, overlapping the *Mountain Limestone*, it practically continued the Pocono beaches on to the close of the Subcarboniferous epoch.

Stated Meeting, November 3, 1882.

Present, 12 members.

Vice-President, Dr. I. E. CONTE, in the Chair.

Letters accepting membership were received from C. Rau, dated Smithsonian Institution, Washington, Oct. 25, and from Garrick Mallery, Bureau of Ethnology, Smithsonian Institution, Oct. 28.

Letters of acknowledgment were received from Thomas C. Porter, Easton (111); and the Smithsonian Institution, Washington (110,111).

A circular letter was received from the Department of the Interior, dated Oct. 26.

Donations for the Library were received from the Zoölogischer Anzeiger, Leipsig; Academy at Brussels; Geographical Society, Paris; London Nature; Canadian Naturalist, Montreal; American Academy of Arts and Sciences; American Journal, New Haven; N. Y. Meteorological Observatory at Central Park; Franklin Institute, Philada.; Hon. Thomas H. Dudley, Camden; Signal Service Bureau and U. S. Engineer Department, Washington; and the Chapultepec Observatory, Mexico.

An obituary notice of Ralph Waldo Emerson was read by Rev. C. G. Ames.